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APPLICATION NUMBER: 60/287,946

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RELATED PCT APPLICATION NUMBER: PCT/US02/14141

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Docket No. 5976

**PROVISIONAL APPLICATION FOR PATENT COVER SHEET**

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

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60/287946

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TITLE OF THE INVENTION (280 characters max)					
Distributed Web Server					
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ENCLOSED APPLICATION PARTS (check all that apply)					
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<input checked="" type="checkbox"/> Yes, the name of the U.S. Government agency and the Government contract number are: <u>National Science Foundation, Grant No. CCR-0373377.</u>					

**CERTIFICATION UNDER 37 C.F.R. 1.10**

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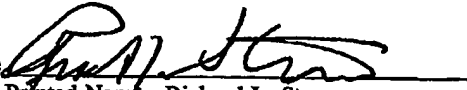
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60287946-050101

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# Boosting Web Server Performance Using DRALIC – Work in Progress

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## I. Introduction

The goal of this work is to design and evaluate a new architecture called DRALIC—Distributed RAID And Location Independence Caching. DRALIC provides a direct and immediate solution to boost web server performance by making use of commodity computers that are available today. DRALIC starts working only when an actual disk request has come to the device no matter whether it is a result of file system miss or it is a request from a database operation. It does not require any change of existing operating systems, databases, nor applications. In one implementation, DRALIC combines the functions of disk I/O host bus adapter card (HBA) and the functions of the network interface card (NIC) to form an integrated I/O-Network card with a highly intelligent embedded-processor. Or in another implementation, DRALIC bridges the HBA and NIC by designing intelligent device drivers. Besides network accesses, the new interface card or drivers at each node control the local disk as well as a raw RAM partition of the system RAM of the node. The disk together with the ones in other nodes in the network forms a distributed RAID that appears to users as a large and reliable logic disk space. The raw RAM partitions in all nodes together form a large, global, and location independence cache for the RAID and is accessible to any node connected to the network, independent of its physical location. Therefore, DRALIC works at device or device driver level to allow all the nodes to work together in parallel to process web requests. The distributed RAID allows parallel operations of disk accesses and provides fault tolerance using parity disks, whereas location independence caches provide cooperative caching to the computing nodes for better I/O performance. Furthermore, DRALIC is a cost-effective architectural approach because it uses low cost PCs/Workstations that are often readily available as existing computing facilities in an organization or cooperation.

## II. DRALIC Architecture

The main idea of DRALIC is very simple. It combines or bridges disk I/O host bus adapter card

(HBA) and network interface card (NIC) to implement distributed RAID and global caching. Figure 1 shows the conceptual diagram of a DRALIC. A disk that exists in a PC/Workstation (node) is partitioned into two parts: one local disk that holds OS and local data and applications, and the other called DRALIC disk that is used by DRALIC. DRALIC disks in all nodes in the system are interconnected through the DRALIC controller and a network switch to form a distributed RAID. The system RAM in each node is also partitioned into two parts: one is controlled by local OS and the other, referred to as DRALIC RAM, is controlled by the DRALIC driver. The collection of DRALIC RAM in all nodes forms a unified system cache for the underlying RAID system.

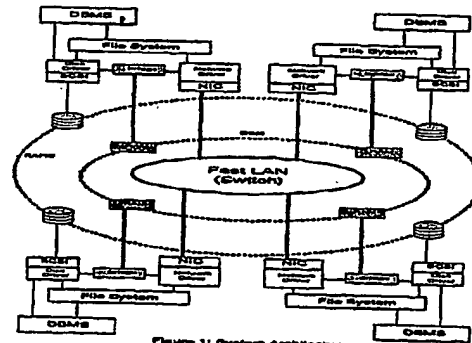


Figure 1: System Architecture

## III. Preliminary Performance Analysis

To demonstrate the feasibility and performance potential of the proposed DRALIC, we present a preliminary performance analysis to look at the effects of bus and network delays on the performance potential of the DRALIC architecture. While our research will focus on System I/O, the current PCI bus can run at 33-132 MHz with data width of 32 or 64 bits. The memory bandwidth of PCI based system is  $BW_{mem} = 33M * 32bits/sec = 132MB/sec$ . A Gigabit Ethernet switch with the transfer speed up to 1Gbps can provide network bandwidth approximately:  $BW_{net} = 100MB/s$ . The overhead of network operation

including both software and hardware is assumed to be  $OH_{net}=0.2ms$ . As for disks, we consider a typical SCSI disk drive with specifications as the follows:

Model	Capacity	Average Seek Time	Rotational Speed	Average Latency	Transfer rate
UltraStar 16ES	9.1GB	7ms	7200RPM	4.17ms	187.2-243.7MB/s

Based on the above disk parameters, we can assume that a typical bandwidth of disk to be  $BW_{disk}=25MB/s$  and the overhead of disk to be  $OH_{disk}=12ms$ . The following is a list of notations and formulae used in our analysis:

B: data block size (8KB);  
N: number of nodes within the DRALIC system;  
 $H_{lm}$ : Local memory hit ratio;  
 $H_{rm}$ : Remote memory hit ratio;  
 $T_{lm}$ : Local memory access time (ms);  
 $T_{rm}$ : Remote memory access time (ms);  
 $T_{raid}$ : access time from the distributed RAID (ms);  
 $T_{pc}$ : Average I/O response time of traditional PCs with no cooperative caching(ms);  
 $T_{dralic}$ : Average I/O response time of DRALIC system (ms);

$$T_{lm} = \frac{1000B}{BW_{lm}}$$

$$T_{rm} = 1000 \left( \frac{B}{BW_{net}} + OH_{net} + \frac{B}{BW_{disk}} \right)$$

$$T_{raid} = 1000 \left( \frac{(N-1)B}{N \times BW_{net}} + N \times OH_{net} + \frac{B}{N \times BW_{disk}} + OH_{disk} \right)$$

$$T_{pc} = 1000 \left( OH_{disk} + \frac{B}{BW_{disk}} \right)$$

$$T_{dralic} = H_{lm} \times T_{lm} + (1-H_{lm}) \times H_{rm} \times T_{rm} + (1-H_{rm}) \times T_{raid}$$

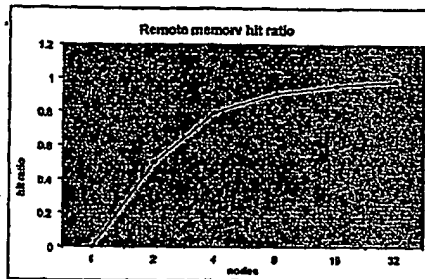


Figure 2: Remote cache miss ratio

With lack of measured hit ratios of remote caches, we assume remote hit ratio to be a logarithm function of number of nodes in the system as shown in Figure 2.

It is reasonable to assume that the remote cache hit ratio increases with the number of nodes because more nodes give larger cooperative cache spaces. The exact hit ratio number is not significant here since we use the hit ratio as a changing parameter to observe I/O performance as a function of it. From Figure 3, we can see that even with hit ratio of 50%, performance is doubled. With remote hit ratio of 80%, a factor of 4 performance improvement can be obtained. The data in this figure are sufficient to show the potential benefits of DRALIC.

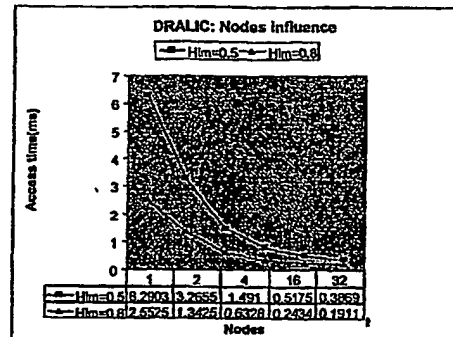


Figure 3: Average I/O response time vs. number of nodes

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